



# Seasonal patterns of carbon and moisture variability with combined AVIRIS and MODIS satellite observations

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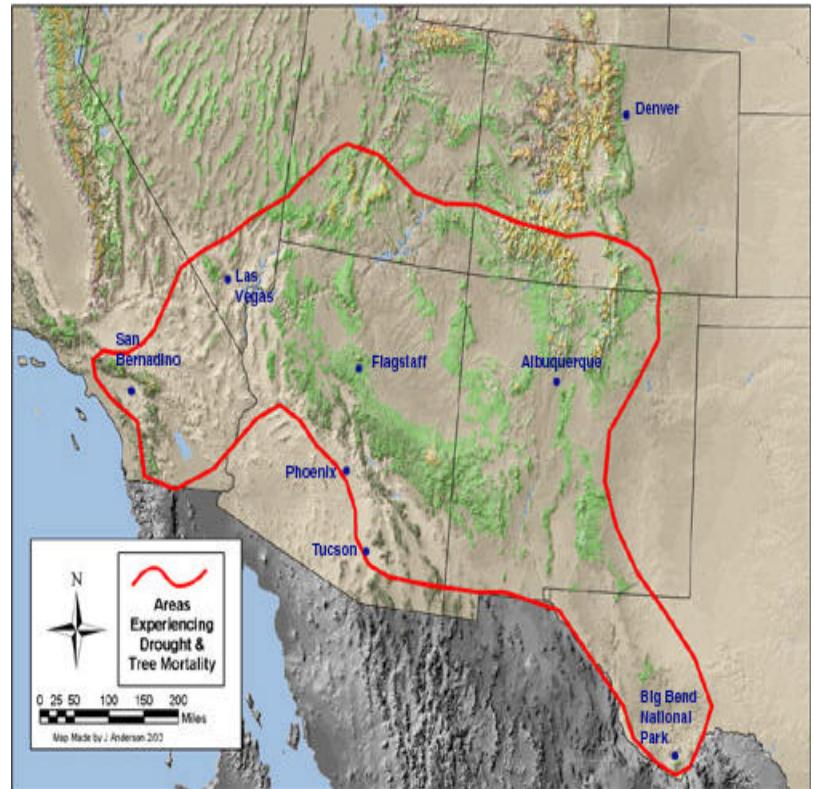
<http://tbrs.arizona.edu>

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\*\*With important contributions and thoughts from Hojin Kim,  
Bill Emmerich, Russel Scott, Travis Huxman, Ed Glenn, Susan  
Moran, Pamela Nagler

# Introduction

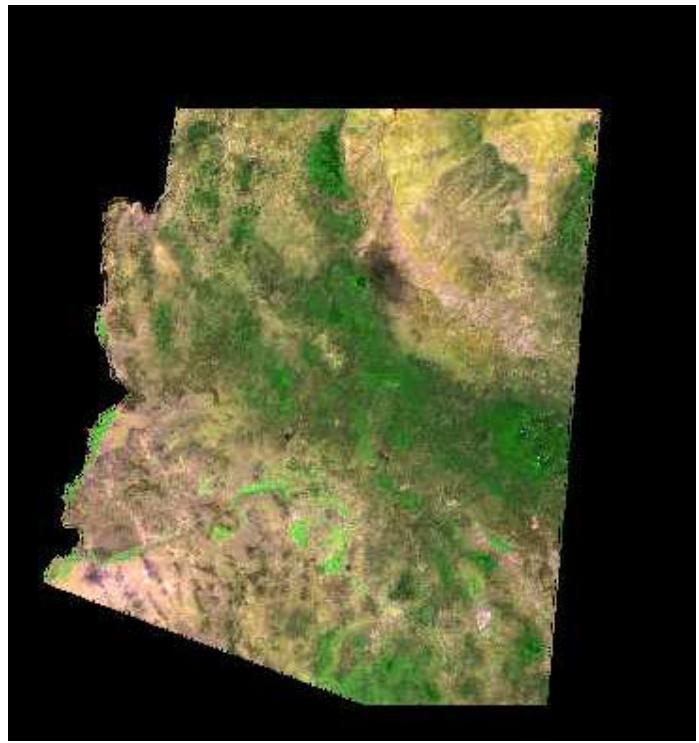
- Climate change and land conversion activities (e.g ranchettes) are rapidly altering biologic activity of arid & semiarid ecosystems in unpredictable ways throughout the Southwest,
  - Woody plant encroachment (Juniper, Oak, Mesquite)
  - Invasive species, Phreatophytes, Plant mortality
- There is a current 6+ year drought in the Southwest causing,
  - Cumulative water deficit problems,
  - Weakened ecosystem health,
  - Vulnerability to land conversions,
  - Increased fire activity
  - Insect infestations
  - Plant mortality



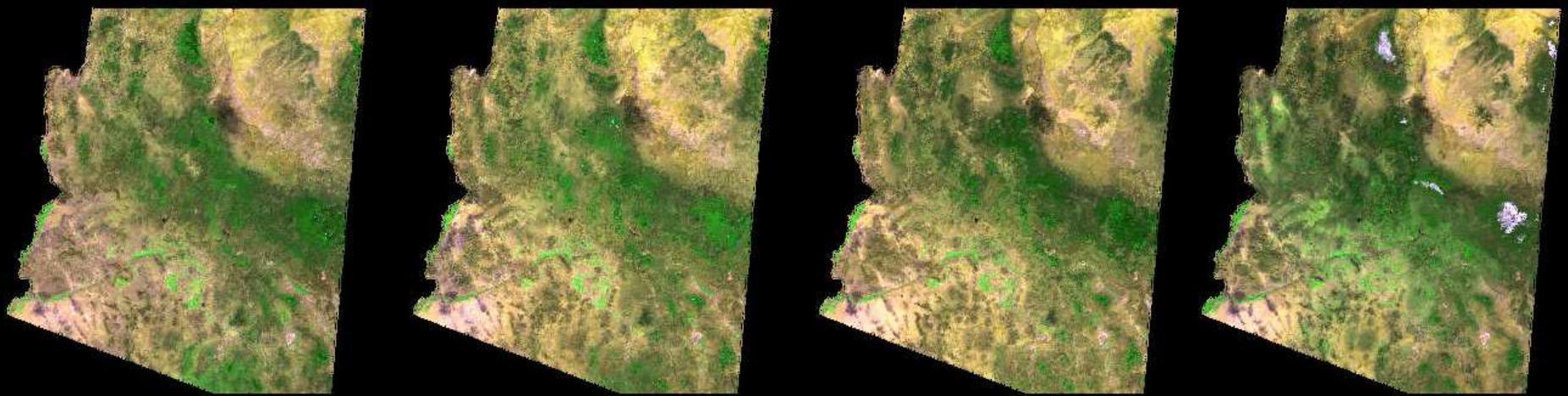
Drought conditions have impacted most of the Southwest from 1996 through 2004 with 2002 being one of the driest in recorded history

# Satellite Time Series Data

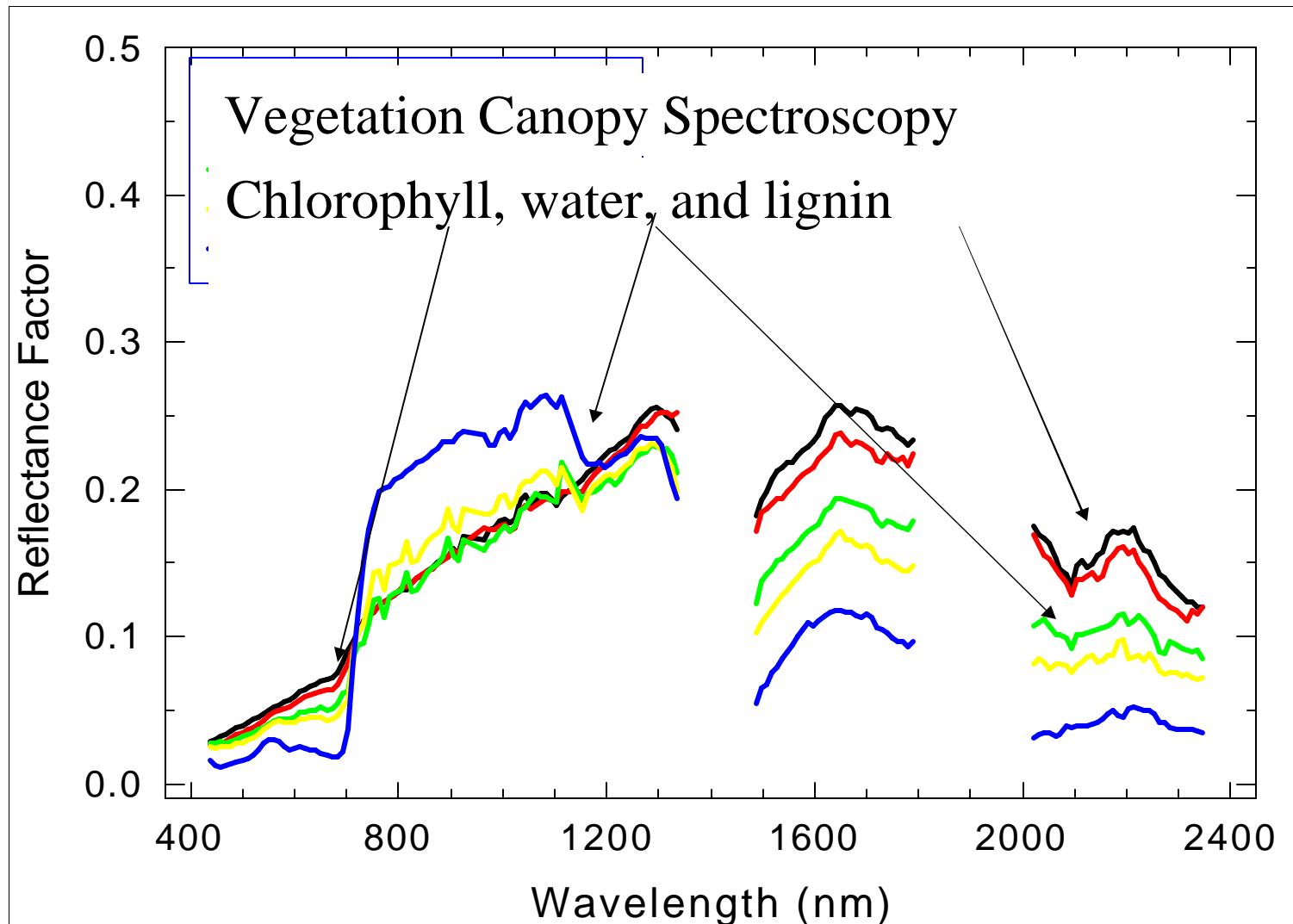
- Satellite monitoring provides information on seasonal and inter-annual vegetation responses over spatial and temporal scales
  - along elevation, latitude, precipitation and species gradients
- High temporal frequency observations with the Moderate Resolution Imaging Spectroradiometers (MODIS) offer unique opportunities to study climate- and land transformations in the temporal domain.



# MODIS Time Series Data



AVIRIS provides hyperspectral data (220 bands) at fine resolution (4m to 20m)



**Leaf and canopy are composed of photosynthetically active vegetation (PAV, chloroplast) and non-photosynthetic vegetation (NPV, e.g., cell wall, branch).**

$$\text{Leaf/canopy (g /m}^2\text{)} = \text{PAV} + \text{NPV}$$

**Scales:** canopy -----> leaf -----> chloroplast  
*(branch, twigs)*    *(cellwall, vein)*

**Plant Area Index**   **Leaf Area Index**

**Fraction of light absorption**

**FAPAR<sub>canopy</sub>** ---> **FAPAR<sub>leaf</sub>** -----> **FAPAR<sub>PAV</sub>**

$$\text{FAPAR} = \text{FAPAR}_{\text{PAV}} + \text{FAPAR}_{\text{NPV}}$$

# Improved vegetation indices over NDVI

## ---- Leaf chloroplast

### Chlorophyll-related vegetation indices

Enhanced Vegetation Index (EVI, Huete et al., 1997)

$$EVI = G \times \frac{\mathbf{r}_{nir} - \mathbf{r}_{red}}{\mathbf{r}_{nir} + C_1 \times \mathbf{r}_{red} - C_2 \times \mathbf{r}_{blue} + L}$$

*Alternative approach to soil water, vapor pressure deficit*

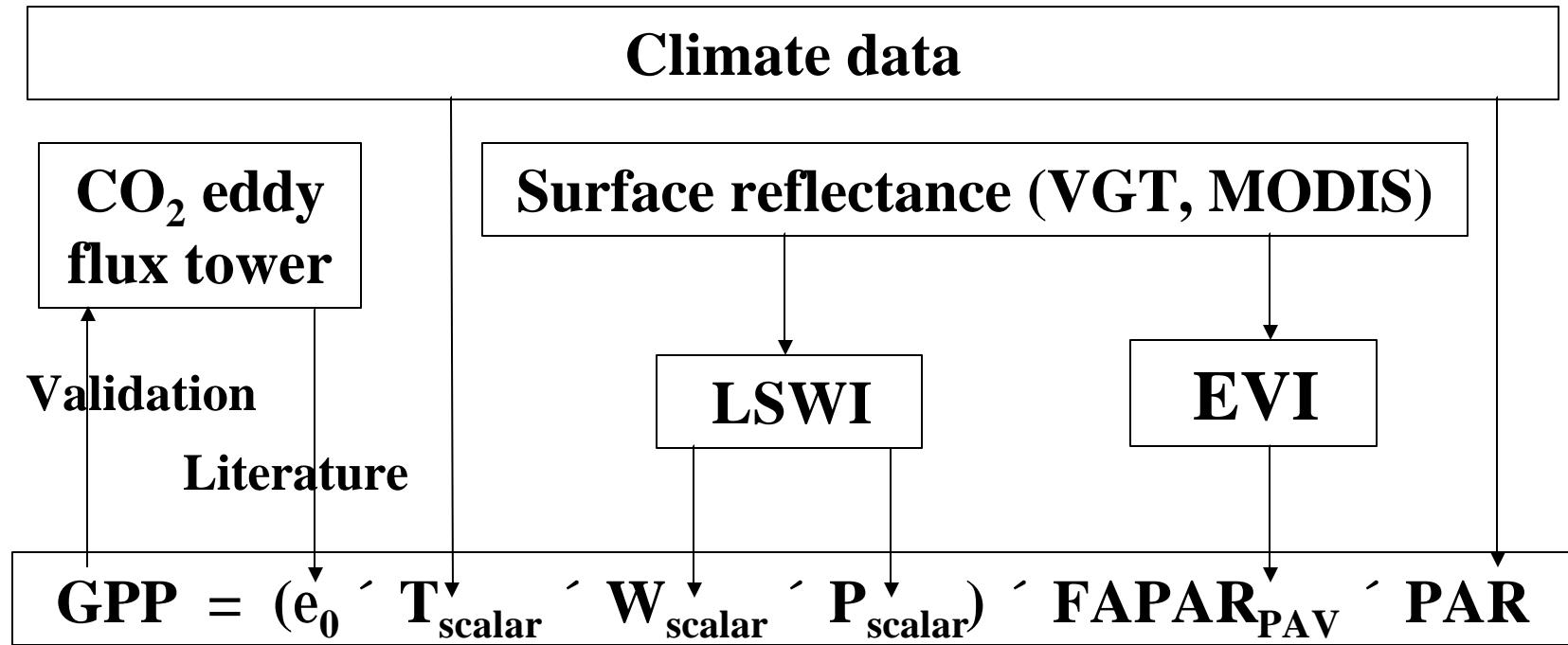
## ---- Leaf water content (g /cm<sup>2</sup>)

### Water-related vegetation indices

Land Surface Water Index (LSWI, Xiao et al, 2002)

$$LSWI = \frac{\mathbf{r}_{nir} - \mathbf{r}_{swir}}{\mathbf{r}_{nir} + \mathbf{r}_{swir}}$$

## Satellite-based Vegetation Photosynthesis Model (VPM)

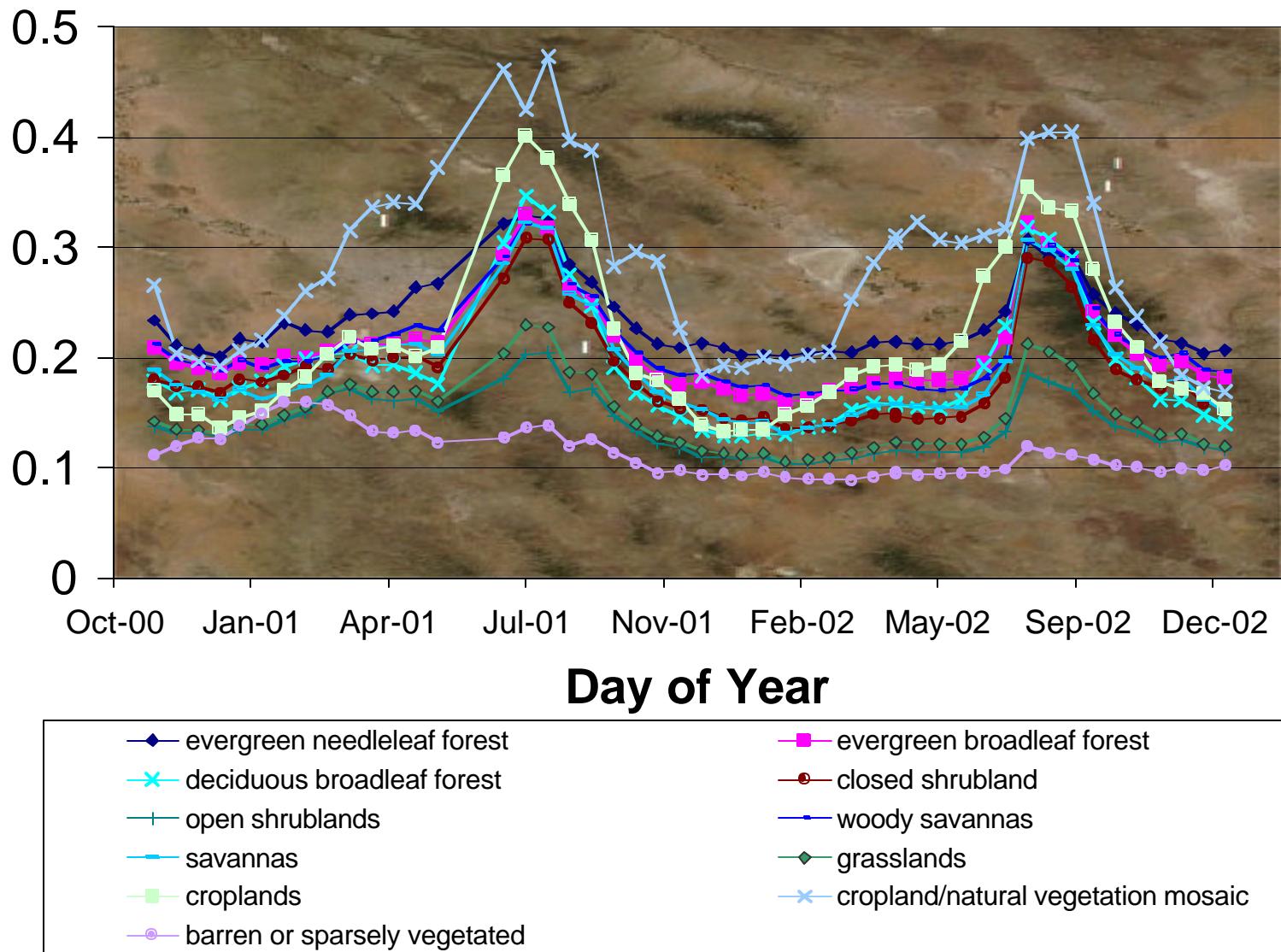


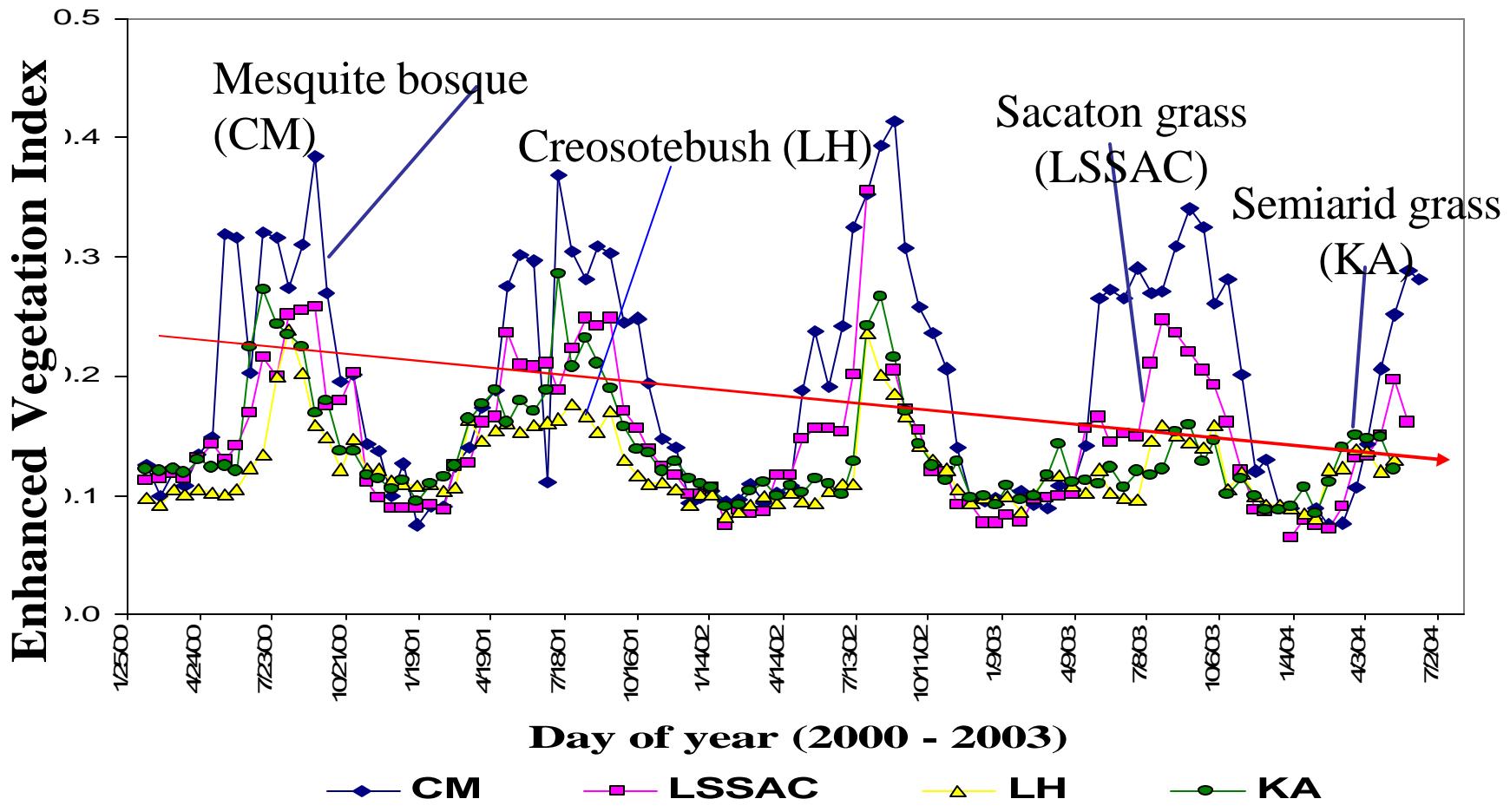
$T_{\text{scalar}}$  – temperature scalar,  $W_{\text{scalar}}$  – water scalar,  $P_{\text{scalar}}$  – phenology scalar

# Research Goals & Objectives

- o Investigate the seasonal and inter-annual patterns of biologic vegetation activity & responses to the severe drought, and associated land disturbances, in the arid and semiarid ecosystems of the Southwest
- o Use advanced chlorophyll-related vegetation indices (e.g., EVI) and water-related vegetation indices (e.g., LSWI) track the seasonal dynamics of biochemical and biophysical parameters at canopy levels.
- o Scaling issues: there is a disconnect between moderate resolution remote sensing data and field and tower observations (chlorophyll and water) of leaf and canopy levels.

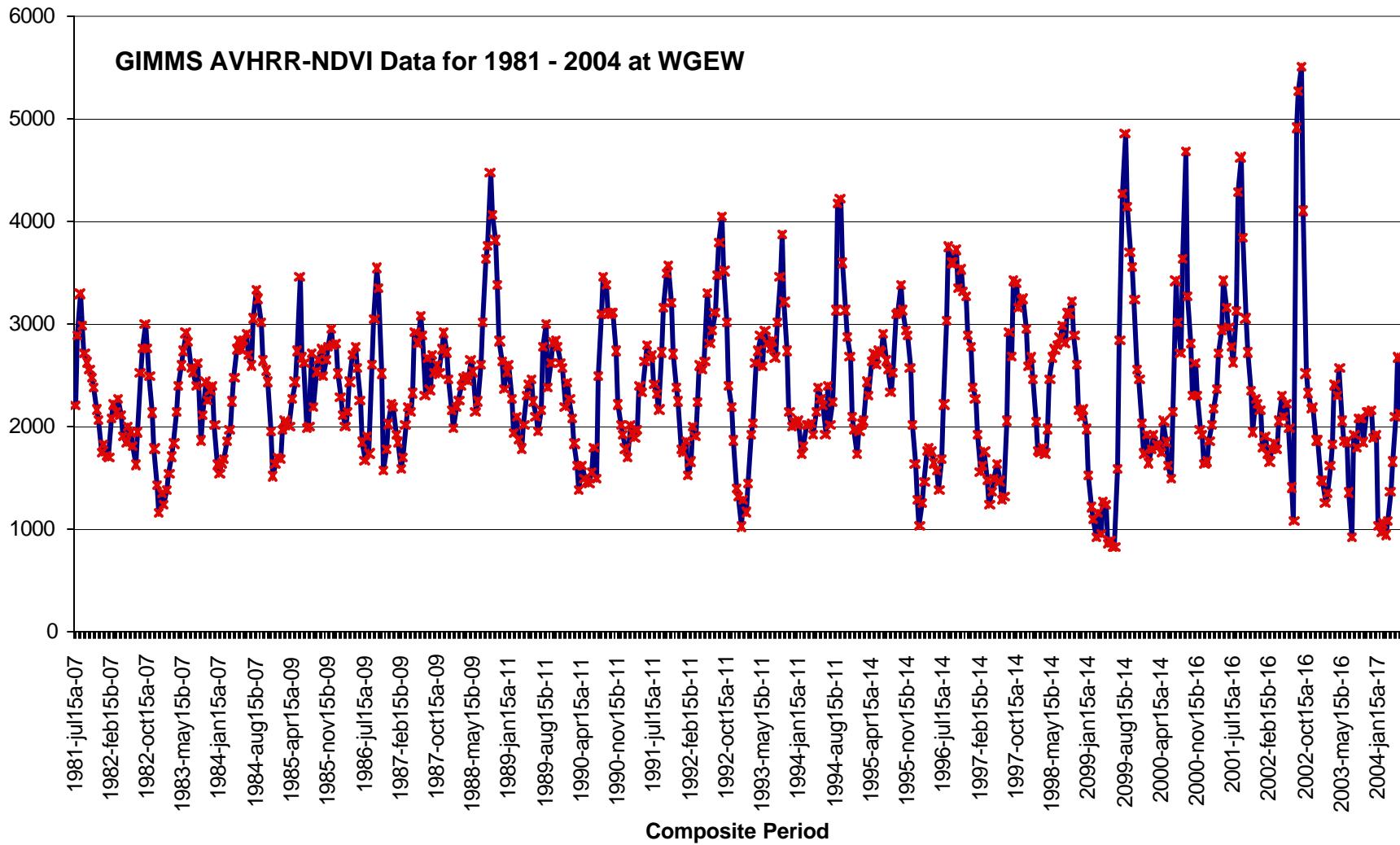
# EVI inter-annual trend per land cover types in S.E. Arizona



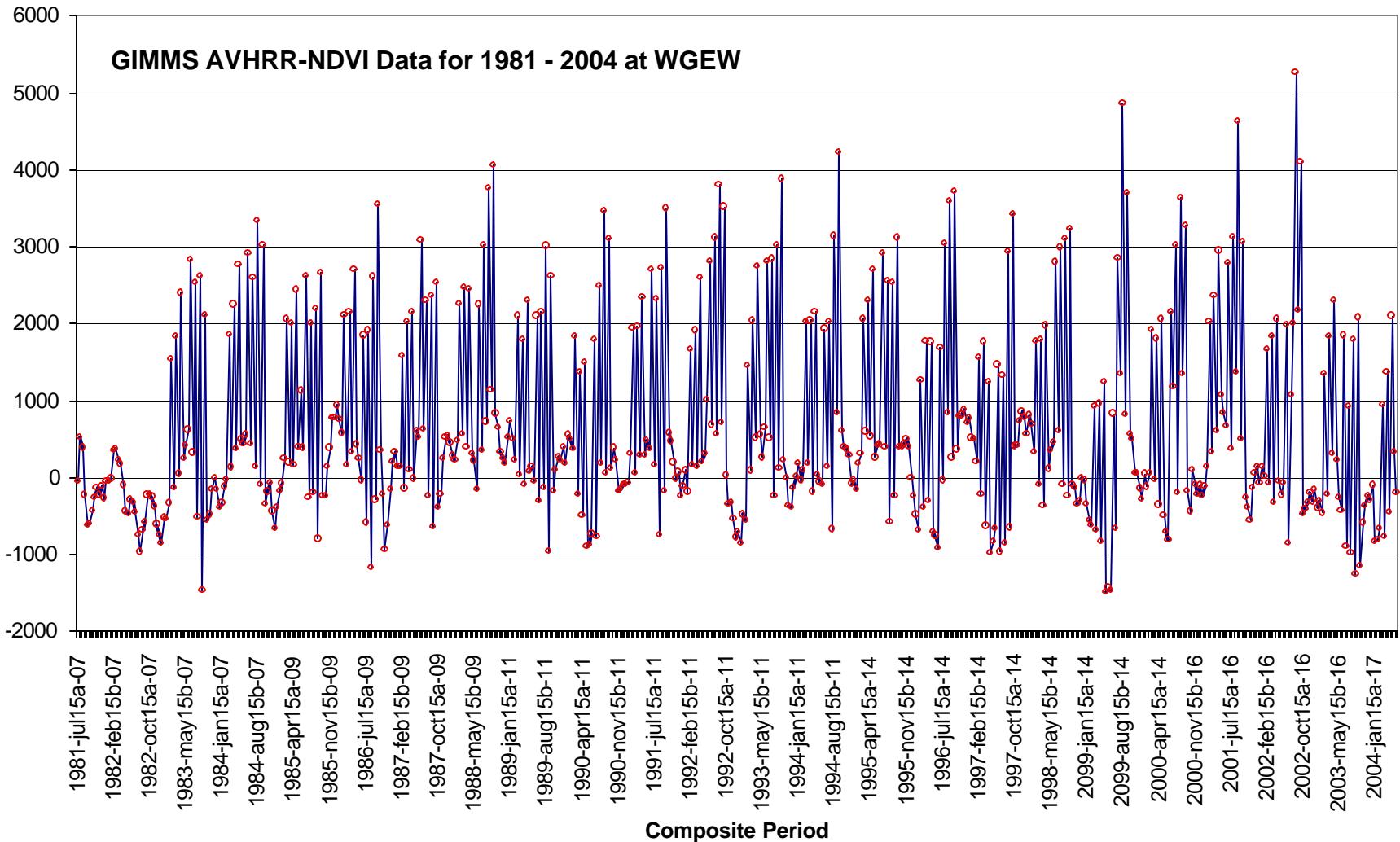


Interannual variations: The riparian communities green-up first, followed by the sacaton grass and then the upland areas.

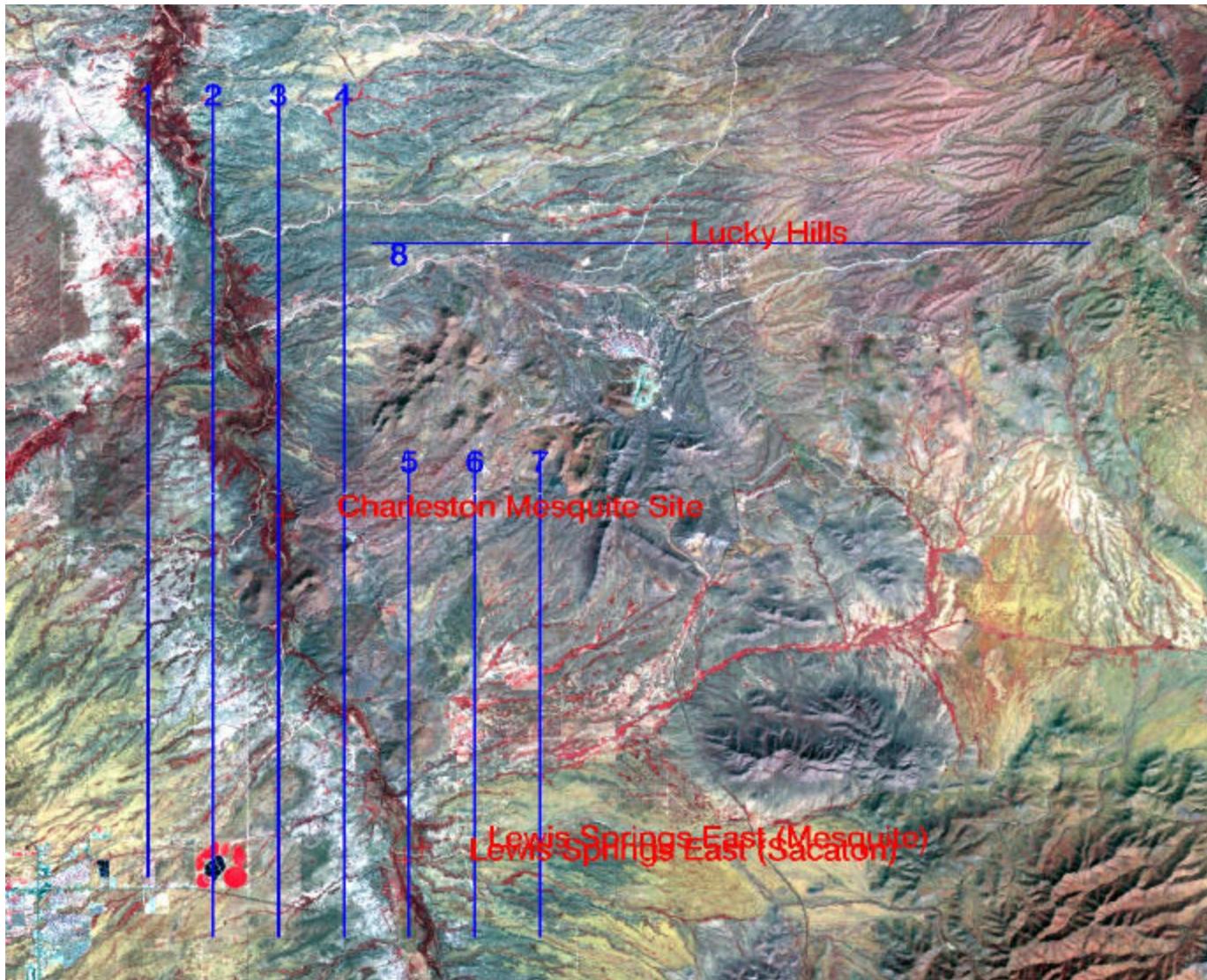
# 20+ year time series of WGEW with AVHRR - NDVI



# 20+ year time series anomalies of WGEW with AVHRR - NDVI



# 2003 AVIRIS flight lines in July and November (4 m resolution; 220 bands at 10nm)



# Charleston mesquite at San Pedro River, July 2003

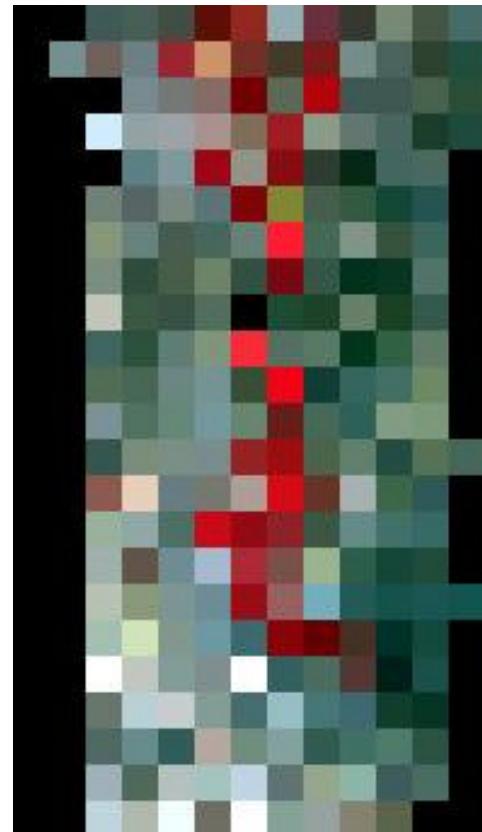
4m



30m



250m



# Lucky Hills site

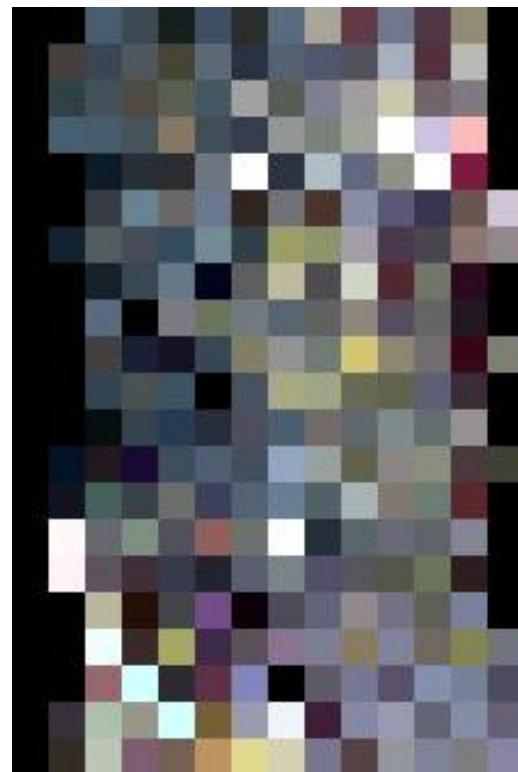
4m



30m

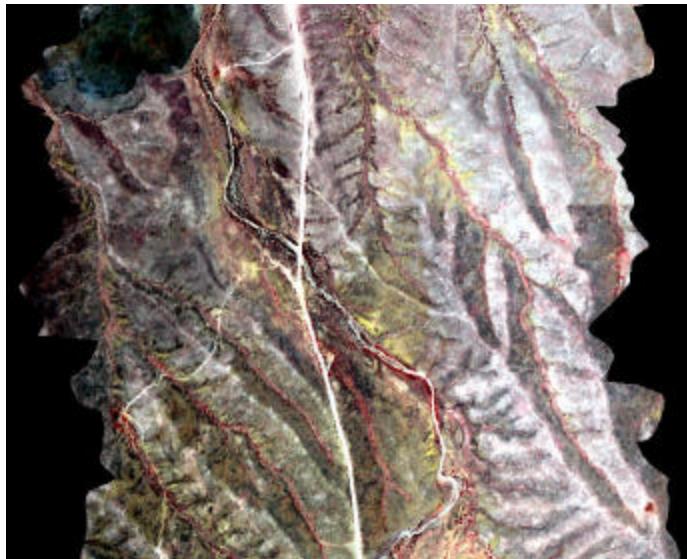


250m

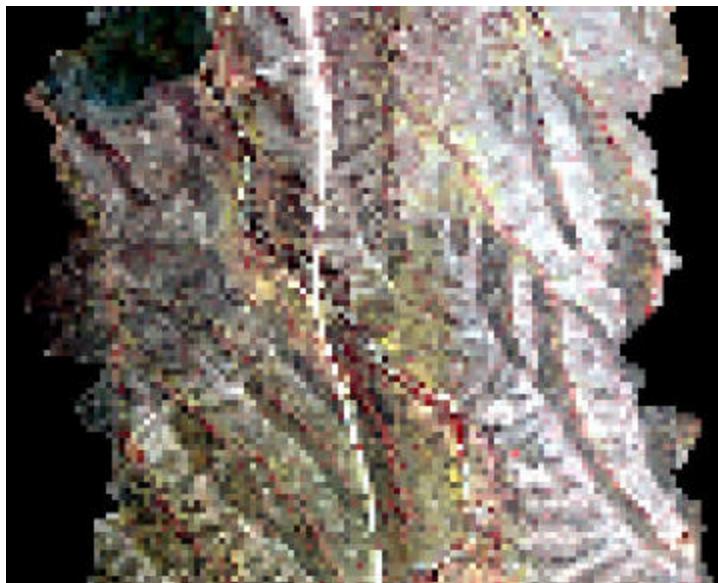


# Wanlut Gulch Kendall grassland site

4m

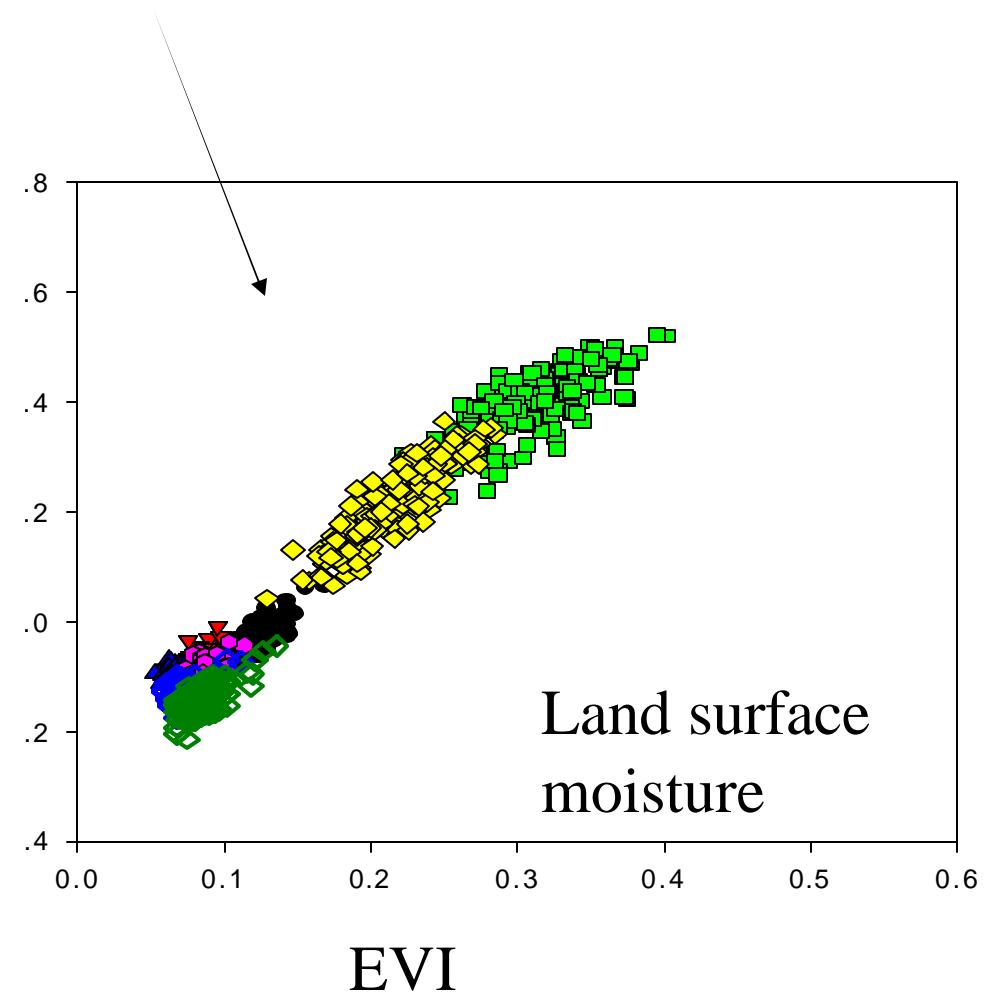
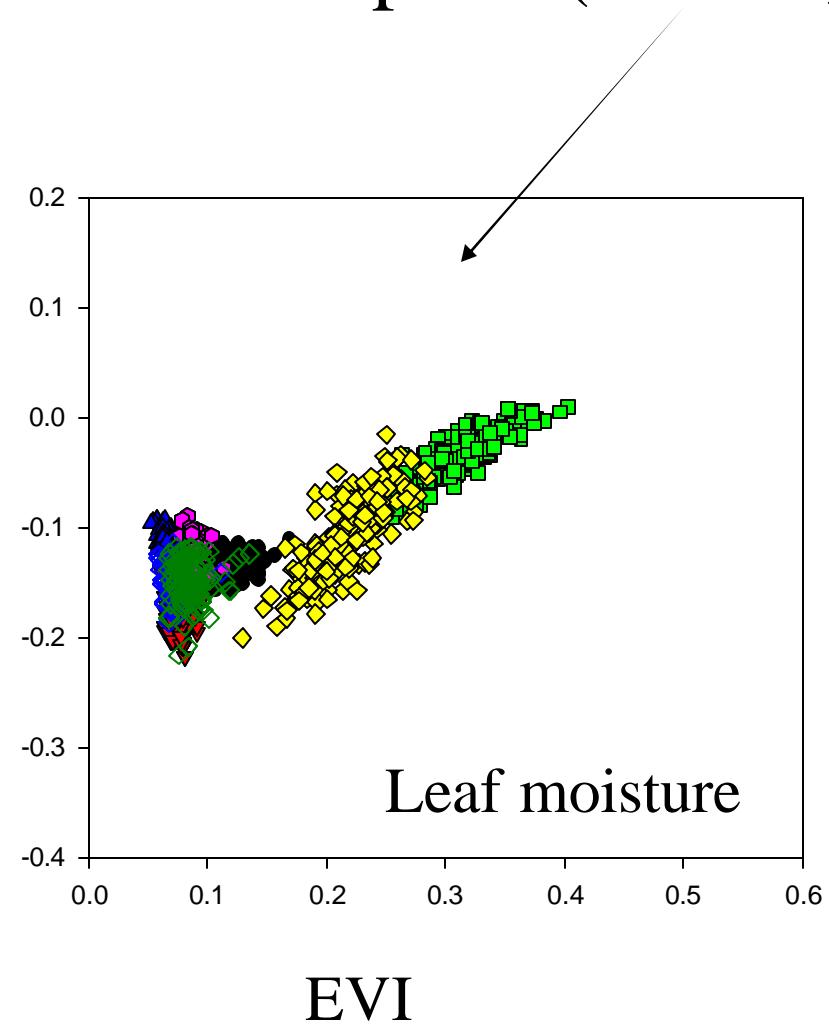


250m

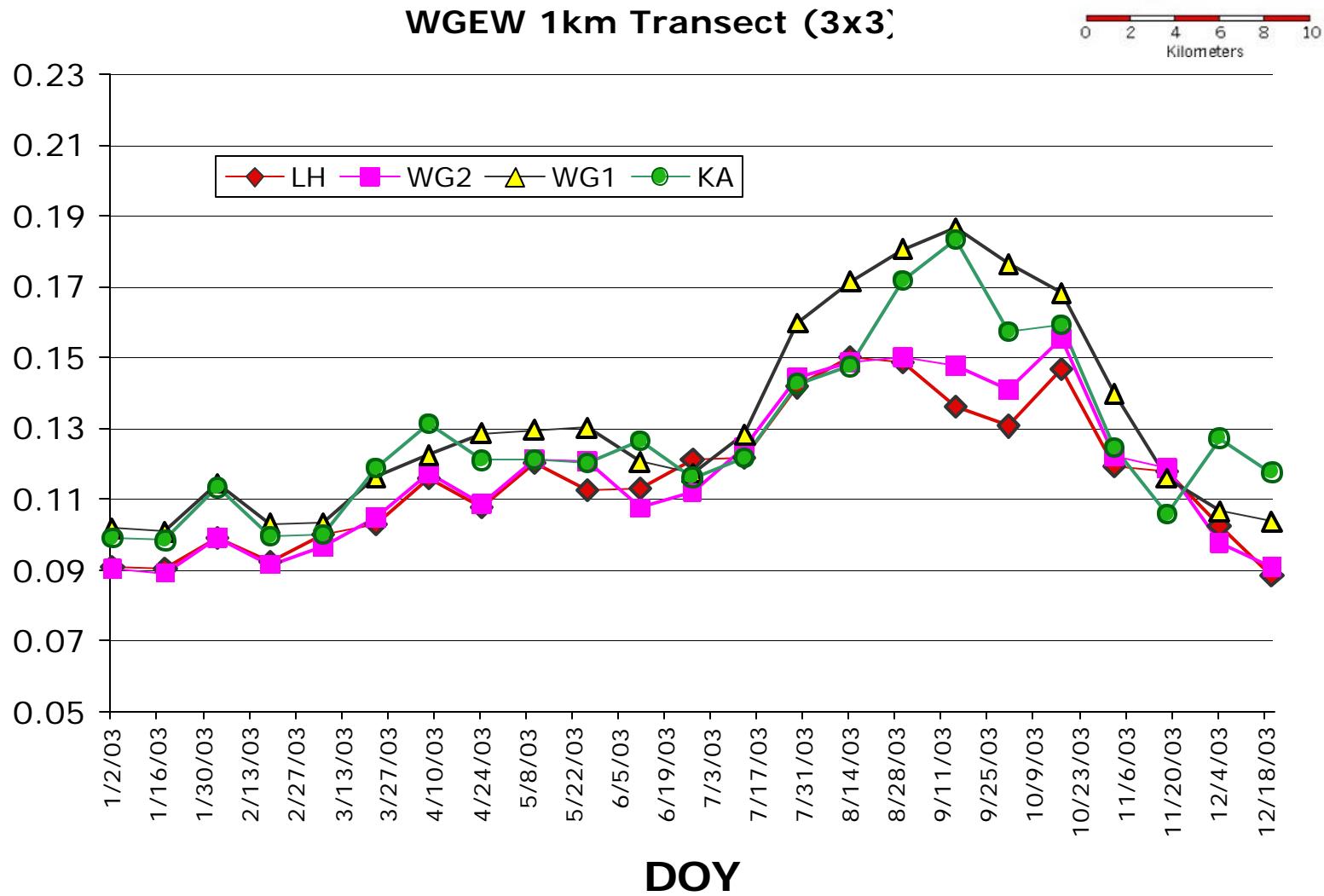
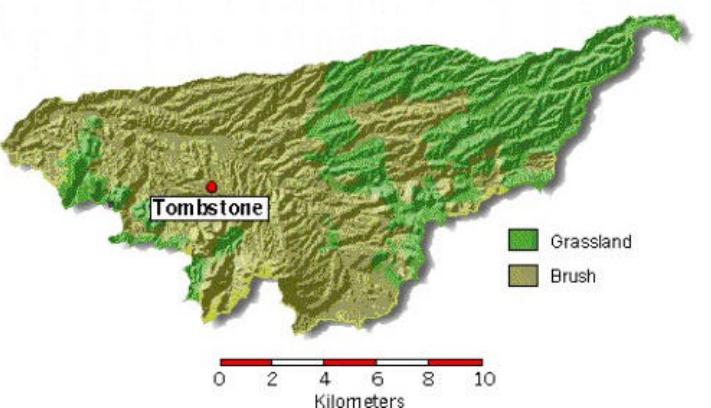


30m

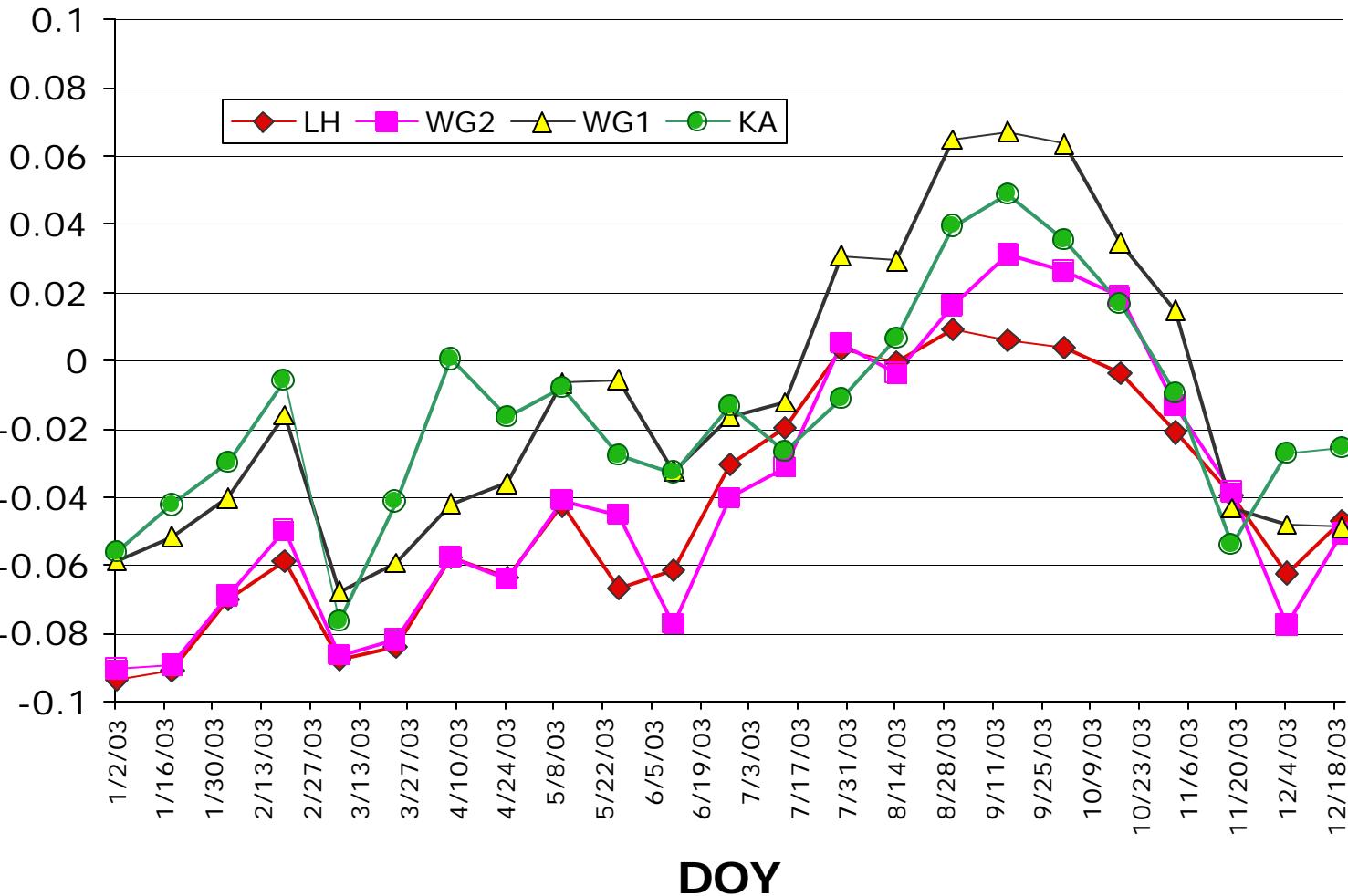
# Vegetation Index(EVI) - Moisture Index Crossplots (NDWI, LSWI)



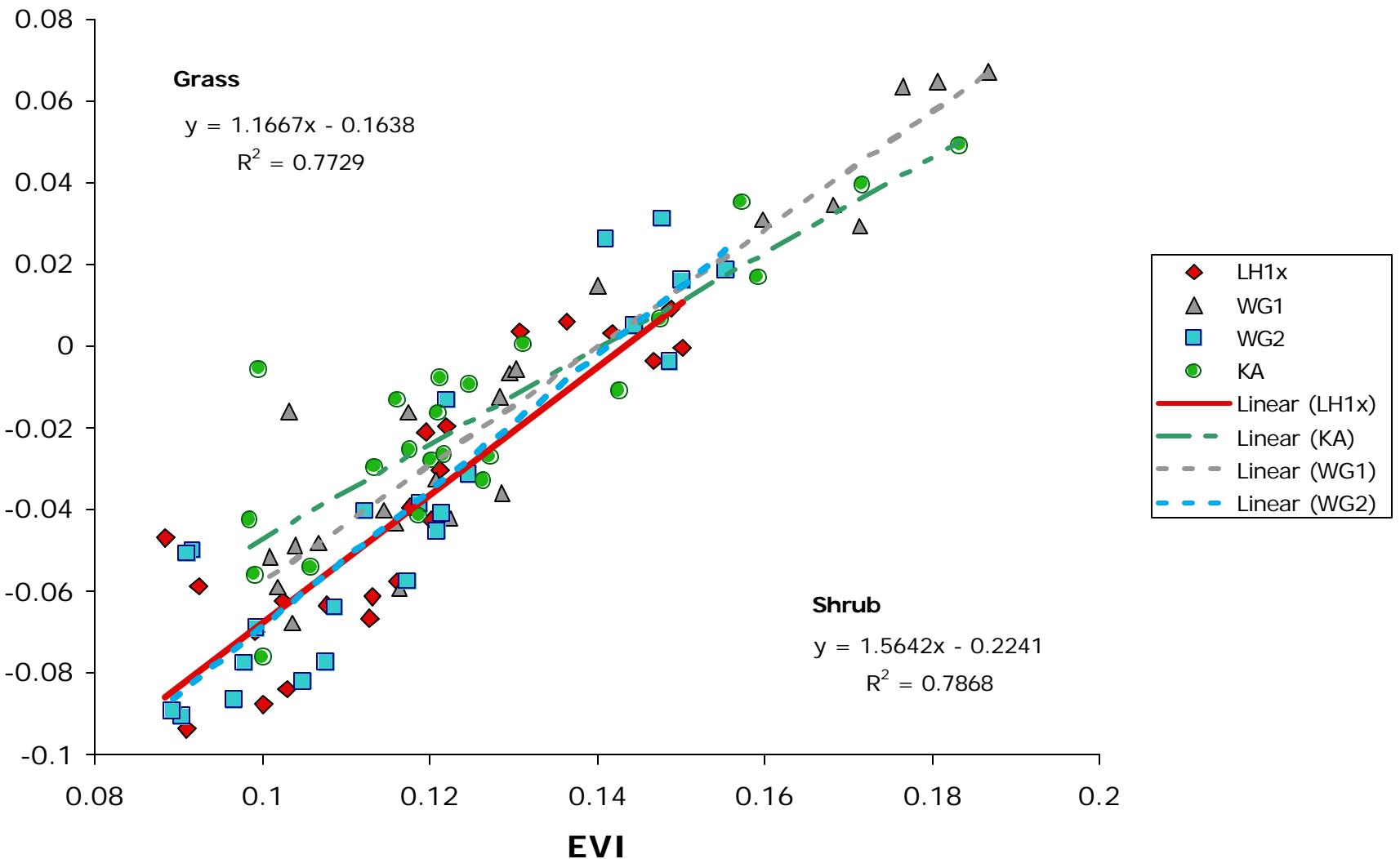
# MODIS seasonal profiles LH to KA



## WGEW 1km Transect (3x3)

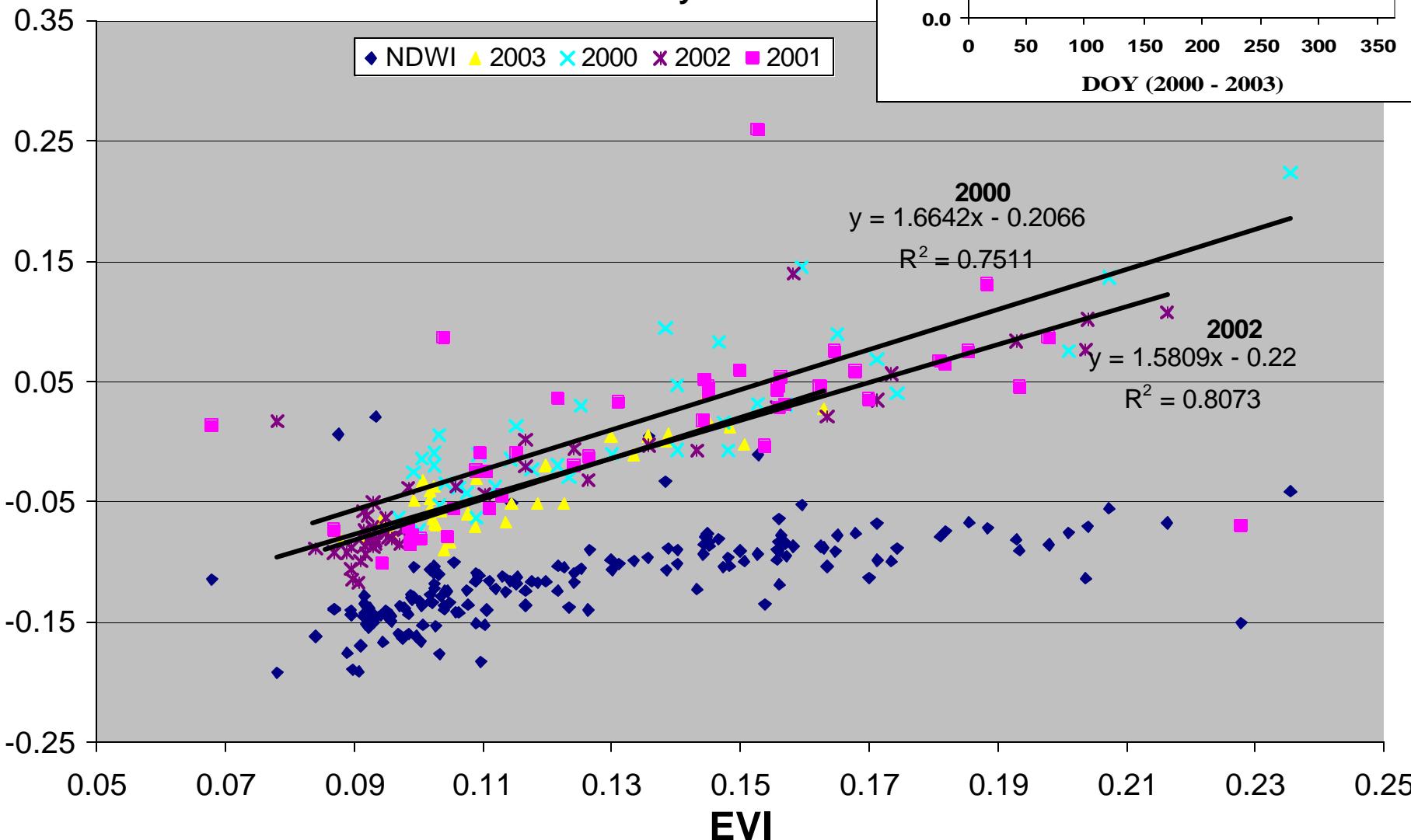


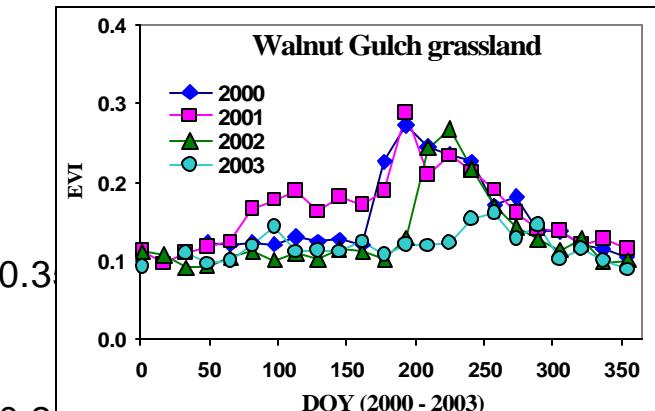
# 1km MODIS (3x3)



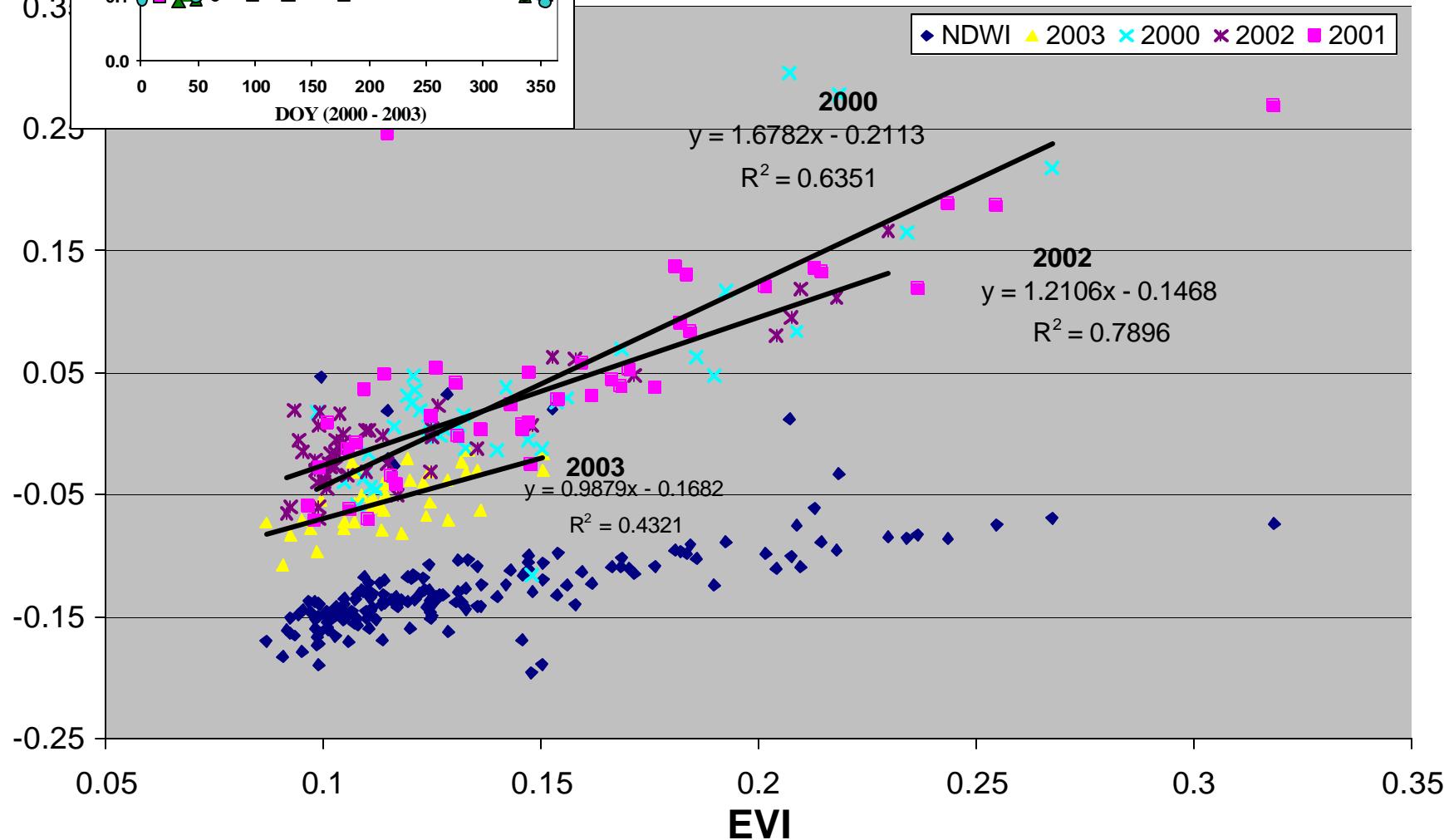
- Slope of LSWI/ EVI increases over shrubs

## Lucky Hills

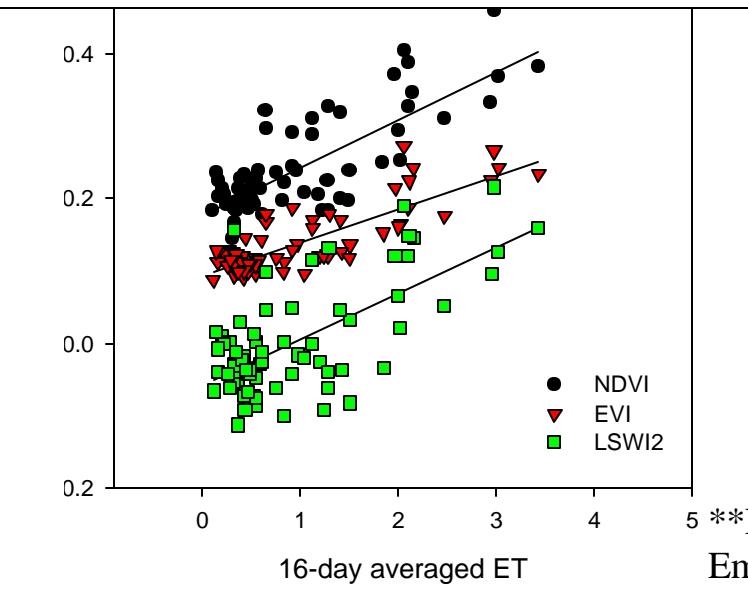
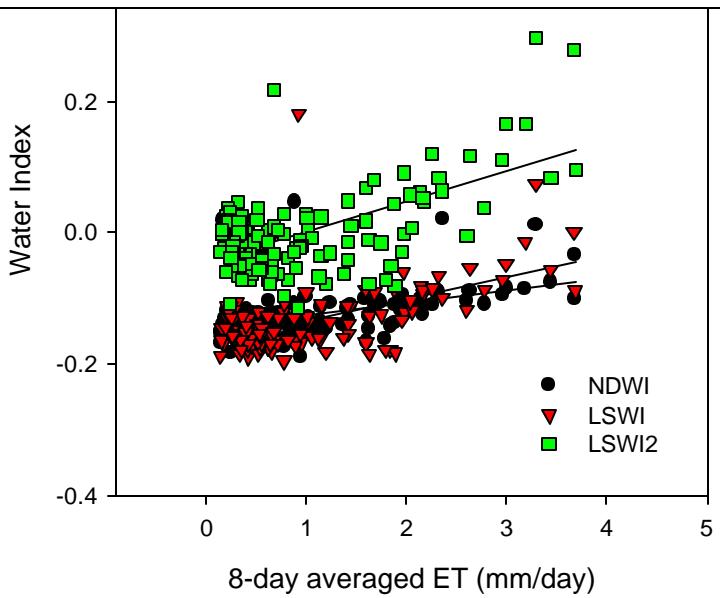
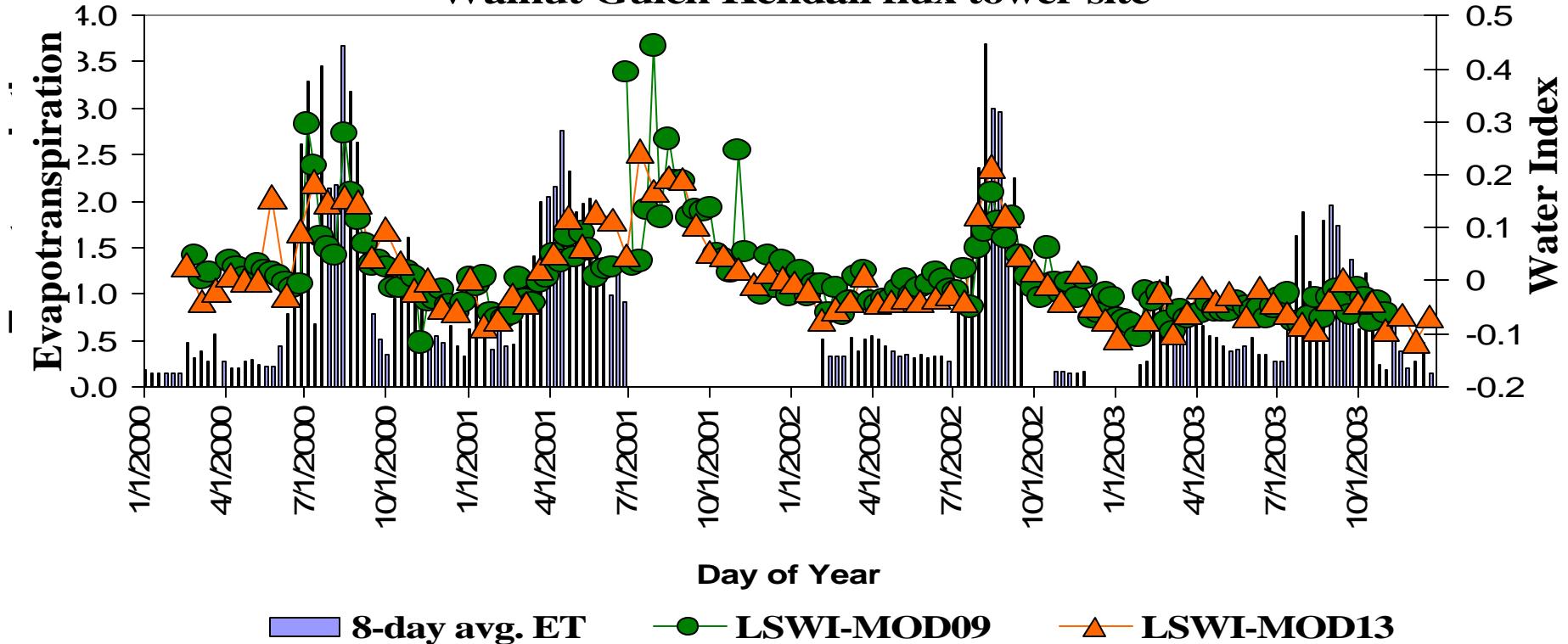




## Grassland

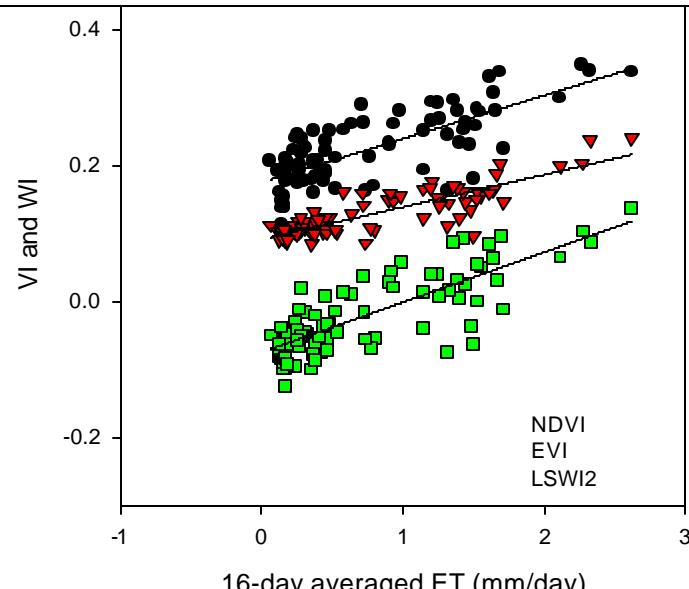
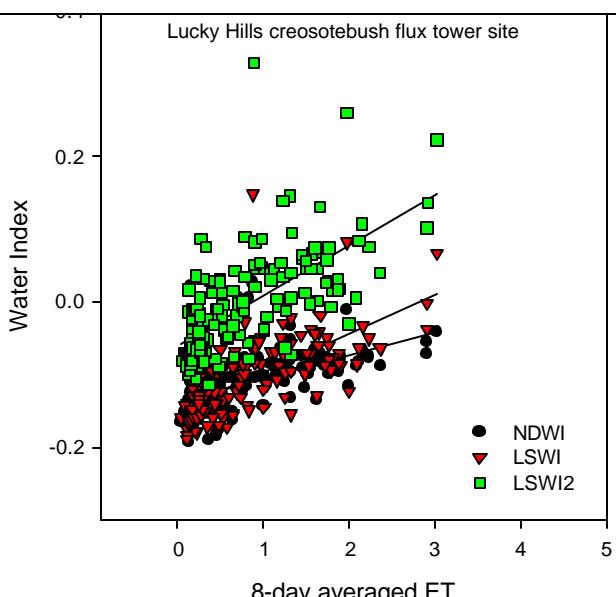
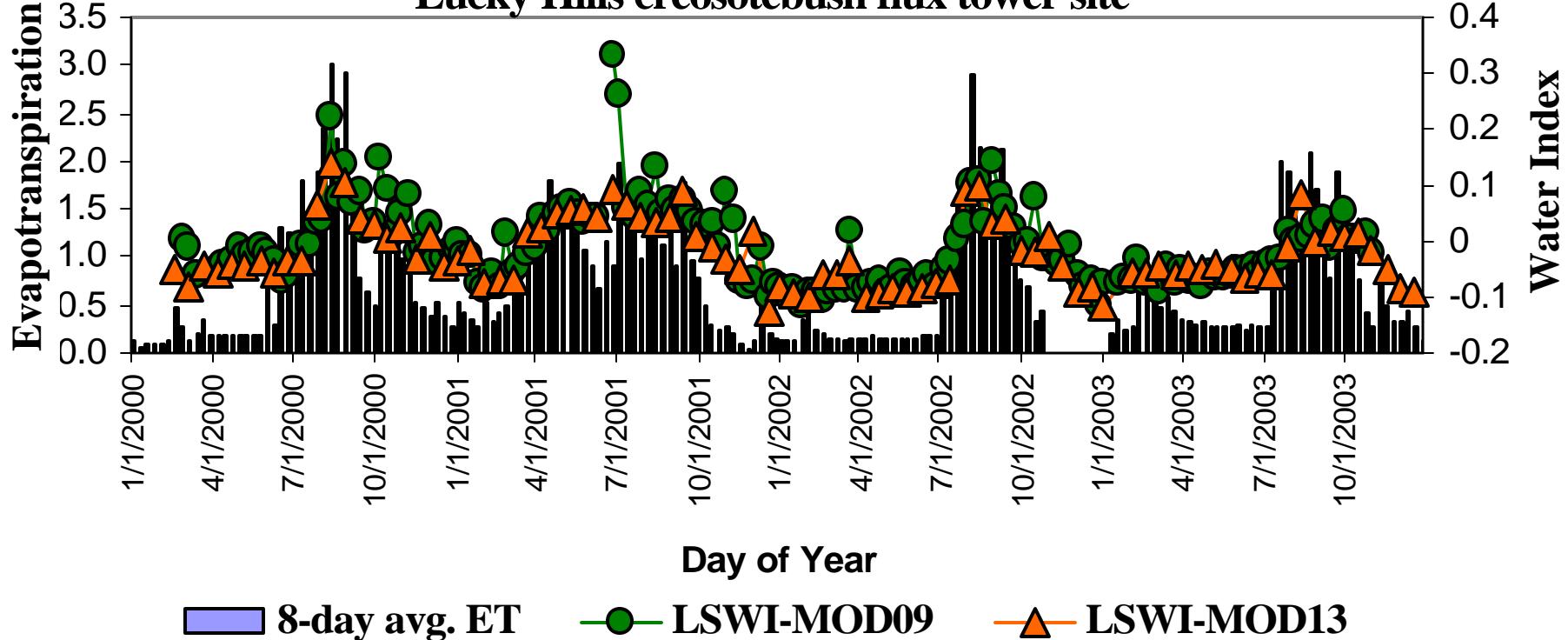


# Walnut Gulch Kendall flux tower site



\*\*ET data, courtesy of Bill  
Emmerich, USDA-ARS

# Lucky Hills creosotebush flux tower site



\*\*ET data, courtesy of Bill Emmerich, USDA-ARS

# Summary

- Chlorophyll and water indices offer insights into upland canopy metabolism,
- Relationships found between remotely sensed data and surface fluxes,
- Coupling and scaling are important directions,
- Are the water indices important scalars?

# WGEW is a key long term community core validation site

